DOW CORNING

A dollar <u>saved</u> is a dollar <u>earned</u>

...and the earnings of many companies are helped by ALPHA Model LFW-1 Friction and Wear Testing Machine.

As an example, take Mueller Brass Company. The LFW-1 machine in their lab is paying its way every day.

Research at Mueller Brass has established the correlation between wear test data from the LFW-1 machine and from a dynamometer gear tester. As a result, Mueller Brass's Gear Blank Division determines wear rates in one day which on a dynamometer gear tester would have required 30 days of testing. Mueller Brass also determines pv data, temperature rise and coefficients of friction on their LFW-1.

If you have a specific application or a problem in friction and wear, please call or write Alpha Molykote Plant, Testing Machines Department, Dow Corning Corporation, Stamford, Conn.

Very truly yours,

Hani T. Azzam

Hani T. Azzam, Manager
Testing Machines Department

HTA:cs
Enc.

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NEW WEAR TESTING METHOD SAVES TESTING TIME

by J. F. Shuler, Project Engineer
Mueller Brass Co.
Port Huron, Michigan

The most direct way to test the wear resistance and friction characteristics of a material is to run it as a bearing—under load against a sliding surface. The sample need not be large or complicated in shape; a small rectangular block will do. But all test conditions such as loading, sliding velocity and temperature must be controllable and repeatable if test results are to be meaningful.

At Mueller Brass Co., Port Huron, Michigan, we have perfected and standardized a wear test procedure for brass, copper, bronze, and aluminum alloys as a part of our continuing materials evaluation program. The tests are run on an Alpha Model LFW-1 friction and wear testing machine manufactured by Dow Corning Corporation, Stamford, Connecticut.

The machine is accurate enough to distinguish the wear difference in forging samples according to the direction in which the samples are cut. *In the case of gears, data obtained from the wear testing machine correlates directly with dynamometer tests—one day of wear machine tests are the equivalent of 30 days of dynamometer tests.* Wear test specimens for the machine are small rectangular blocks easily made in any machine shop at low cost.

The materials evaluation program, instituted at Mueller several years ago, encompasses research for better, less costly materials; establishment of industry-wide materials standards; and production problem analysis both for Mueller plants and their customers. Considerable knowledge of copper-based alloys for bearings and gears has come from the program.

THE TEST MACHINE

The Alpha Model LFW-1, combines simplicity of operation and excellent, repeatable accuracy in a compact setup. Its principle is uncomplicated. The wearing surface is a hardened steel ring—the outer race ring for a Timken bearing. The outside diameter of the ring rotates against a small, flat-surfaced block made of the material to be tested.

Normal force (or the test load) at the contact area between the ring and the flat wear surface is attained by means of weights and linkages. The tangential force developed as a result of friction is measured and recorded. Temperature, a vital factor in the tests, is also measured and recorded. Fig. 1 illustrates the principle, Fig. 2 the test setup.

Any one of several factors can be chosen to determine the end point of a test. One of these factors is the number of revolutions made by the ring; a timer may stop the test after a suitable period at a specific speed.

Our setup includes a recording strip chart for the tangential friction force in addition to the normal friction gauge. The machine can be set to stop at a predetermined friction force.

Wear of the sample under test is easy to read. At Mueller Brass, the weight arm has been graduated in increments. When the arm moves down one graduation, it indicates the test piece has worn away 0.001″. The machine can be set to shut off when a predetermined amount of wear occurs.

Thoughtful design makes the Alpha testing machine a precision research tool. The machine applies and maintains loading with a maximum error of ±1 percent, and holds sliding velocity within ±2 percent. Distribution of load over the area of contact stays within ±5 percent; a larger deviation would place the load factor out of control. The relative position of ring and test piece is held within precise limits, also. If the test piece and ring were to wander minutely from side to side, wear-in of the test material would be out of control.

Test parameters which can be closely controlled in the machine include: (1) ring speed in rpm, (2) type of lubricant, where one is used, (3) duration of the test, (4) loading at the wear point, and (5) temperature.

The Timken ring, specially made for the purpose, can be rotated at any speed between 0 and 200 rpm. At 180 rpm, the normal test speed, sliding velocity equals 65 feet per minute. Hardness of the ring is 60 Rc. A new ring is used for each test. Where necessary, a ring of different material can be substituted for the steel one to determine other metal-to-metal friction ratings.

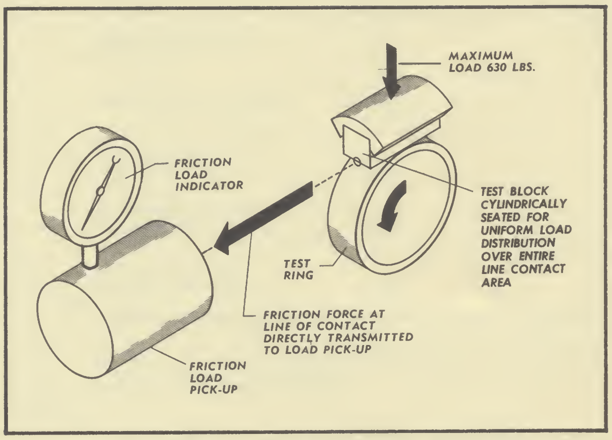

Fig. 1—Alpha LFW-1 machine tests friction and wear characteristics of material by pressing flat surface of sample against rotating ring. Calibrated pressure and constant ring speed yield friction and wear rating. Hertz pressures to 100,000 psi are easily attained in line contact area of sample.

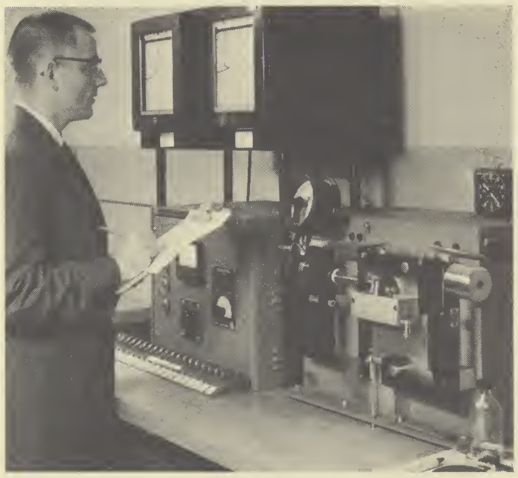

Fig. 2—Friction and wear test setup at Mueller Brass Co.'s research division provides fast answers in wear and friction studies. Regular block specimens are made inexpensively in company machine shop. Test takes less than an hour. Machine supplies all of the constants; the only variable is the test piece.

Lubricant for test pieces is contained in a temperature-controlled well under the ring, Fig. 3. A hotplate controls the oil heat, and a chart recorder records the temperature. A special control has been added to the heater to hold more accurate adjustment of the oil temperature.

Loading at the wear point is produced by hanging weights on the lower end of a 30 to 1 compound lever system. A force of 100,000 psi (average Hertz pressure) can be exerted easily in the line contact area between test piece and ring. Test force on the specimen may be varied between 30 and 630 lb.

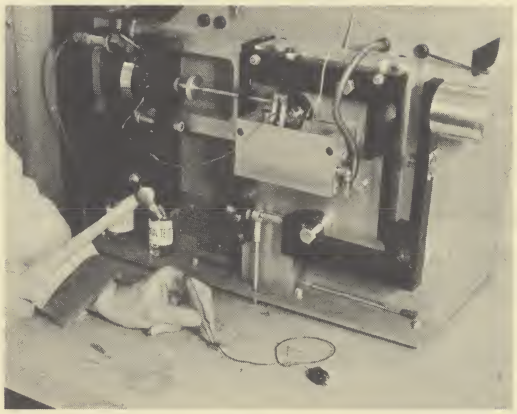

Fig. 3—Close-up view of Alpha friction and wear testing machine at Mueller Brass Co. showing Timken ring rotating against test piece. Friction load is transmitted to indicator at left. Rectangular well under specimen contains lubricant at controlled temperature. Engineer embeds thermocouple in test piece to record rise in specimen temperature during test.

TEST SPECIMENS

Test pieces for the Alpha LFW-1 tester are simple rectangular blocks made inexpensively in any plant tool room. Our standard test blocks measure ¼″ wide by 0.4″ high by 0.620″ long. Width tolerance of the block is +.005″, —.000 so that it is 1/64″ less than the ground area of the ring's outside diameter. This makes certain the wear scar will extend across the wear face. Block height tolerance is ±.0005″ to minimize taper so that loading is uniform. Smaller blocks may be used in an adapter where size of the sample part won't permit larger specimens. Six to 12 pieces are run per test, never fewer than 3.

Test pieces are weighed before and after testing with a thermocouple attached. These weight readings are made carefully, and used to cross-check wear-scar measurements. In some tests, wear particles are collected and weighed.

Surface roughness is measured before a test is run. It has been found that a finish better than 30 microinches does not yield significant improvement in friction readings for copper-base alloys.

TEST RESULTS

Although this equipment can measure many variables, our research is aimed specifically toward evaluating only the differences in materials. Constants are chosen and set into the tester so that the sole variable is the material under test. These constants include: Sliding speed, normal force, the ring, the lubricant, and test duration. Test measurements from the machine observed and noted are friction force developed and temperature of the specimen.

When the test is completed, the projected area of wear is measured using a stereo microscope, Fig. 4. Test results are stated in terms of pressure, which is the applied force divided by the projected wear-scar area.

Fig. 4—Projected area of wear scar is determined using stereo microscope. Mueller procedure records all data on sheet that travels with specimens. Engineer can tell wear difference in samples according to direction they were cut from forging.

TABLE I

MATERIAL	CHEMICAL PROPERTIES							MECHANICAL TEST PROPERTIES				FRICTION TEST DATA FROM LFW-1 MACHINE		
	Cu	Zn	Mn	Pb	Si	Ni	Sn	.2% Offset Yield Strength PSI	Ultimate Strength PSI	Percent Elongation %	Rockwell Hardness "B"	Kinetic Coefficient Friction Max.	Temp. Rise of Above Ambient	Final Pressure X Velocity Factor
FORGED LEADED MANGANESE SILICON BRONZE (Dynalloy 603)	59.5	REM.	2.5	1	1			43,800	73,800	26	79	0.100	22	152,000
CENTRIFUGALLY CAST NICKEL TIN BRONZE	REM.					1.5	10	28,900	51,800	8	68	0.150	21	86,000
SAND CAST NICKEL TIN BRONZE	REM.					1.5	10	30,700	38,700	6	66	0.133	29	73,000
SAND CAST TIN BRONZE	REM.						11	25,300	34,970	8	54	0.167	32	68,000
CENTRIFUGALLY CAST TIN BRONZE	REM.						11	29,500	50,360	6	68	0.167	32	64,000
STATIC CHILL CAST TIN BRONZE	REM.						11	29,600	48,800	9	69	0.167	32	57,000
STATIC CHILL CAST NICKEL TIN BRONZE	REM.					1.5	10	30,400	48,800	18	64	0.150	27	55,000

Table I — Comparison of test data for bronze samples shown in Fig. 5.

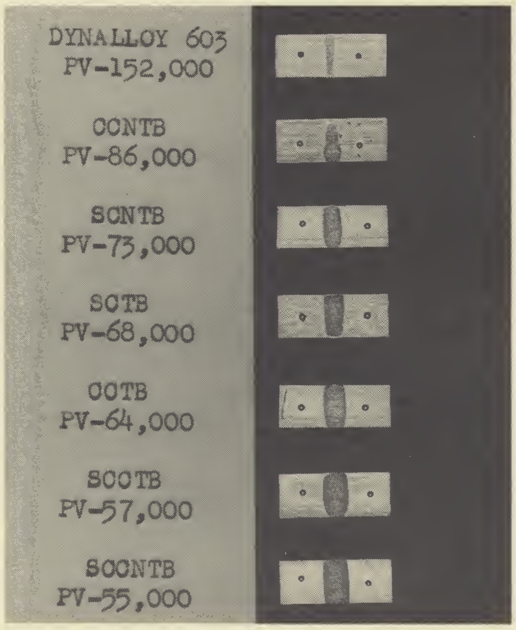

Fig. 5—Scars in test pieces after half hour run in Alpha testing machine tell how well bronze alloys wear. Each piece was run 30 minutes under 30 lb. load at 65 fpm.

Test data shown in Table I are the result of using a 30-lb. load, spindle oil lubricant, 65 fpm sliding speed, and a 30-minute test cycle.

The pressure-velocity values in the last column are the product of the surface-velocity and the normal pressure. These values were definitely stabilized by the time the half-hour test was completed, indicating that they are accurate for the sample material. The worn test specimens are shown in Fig. 5.

Note that in the data there is no correlation between hardness of a material and its coefficient of friction, nor is there any between hardness and temperature rise. A factor that does correlate with the wear tests, however, is the microstructure of the materials.

Our initial research was pointed toward finding reasons for these phenomena to improve quality of bronze worm gears and bearings. Dynalloy 603, a forged, leaded manganese-silicon bronze (which, in these tests, demonstrated the greatest resistance to wear) has a relatively hard matrix of copper-zinc alloy containing a distribution of extremely hard manganese-silicide particles. The hardness ratio between particles and the matrix is about 10 to 1. The hard particles in conventional cast copper-tin alloys, simple crystalline phases of the basic alloy, have a ratio of only 3 to 1.

This difference is reflected in the faster wear rates of the copper-tin alloys.

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Printed in U.S.A.

Form No. 06-084